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DETONATION SHOCK RADIUS EXPERIMENTS (BRIEFING CHARTS)

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CONFERENCE BRIEFING CHARTS

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2007 APS – 15th Topical Conference
on Shock Compression of Condensed Matter, Hawai'i

Detonation Shock Radius Experiments

June 2007

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Outline

- **Background**
  - **Detonation Shock Dynamics**
  - **Hot Spot Size and Initiation**
- **Characterization Experiments**
- **Summary**

Acknowledgements

Ed Wild and Lt. Martin, AFRL/MNMF

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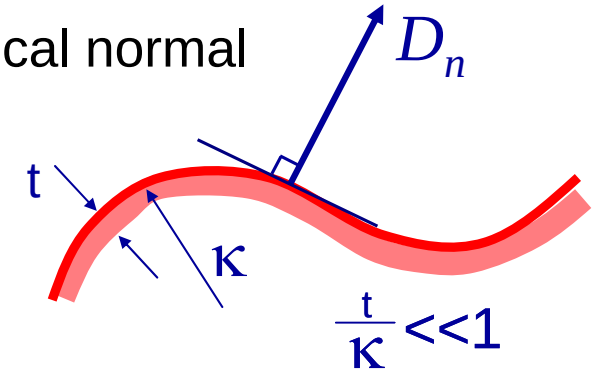
Detonation Shock Dynamics – 1st Order

University of Illinois, Prof. Scott S. Stewart

- Relationship between local wave curvature and local normal detonation velocity

$$D_n = D_{CJ}(1 - \nu\kappa)$$

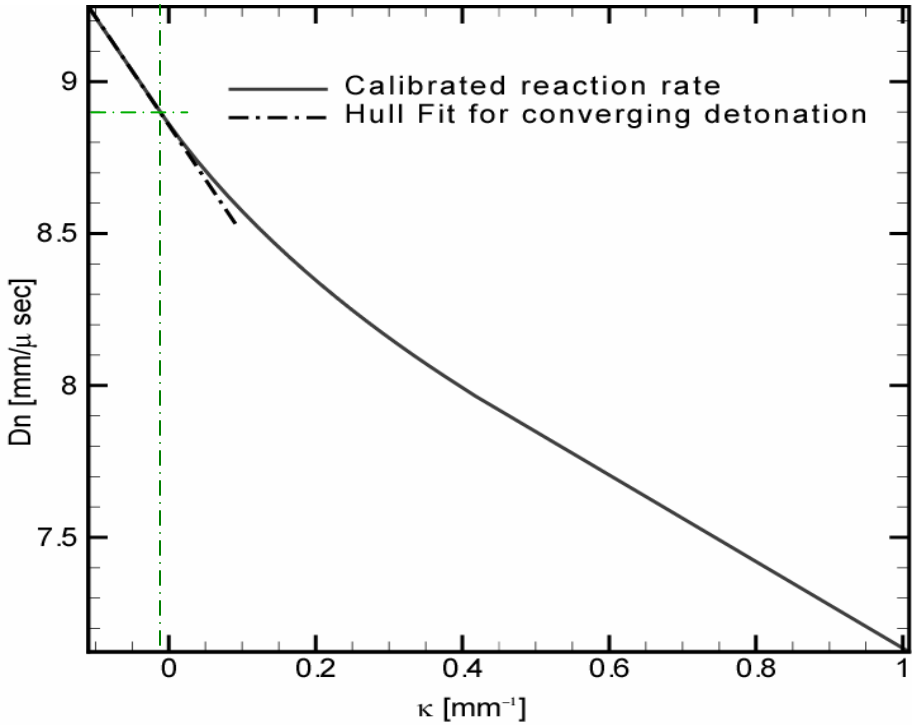
$$\kappa = \frac{f''(x)}{\left\{1 + [f'(x)]^2\right\}^{3/2}}$$



D_{CJ} = steady state Chapman-Jouguet velocity

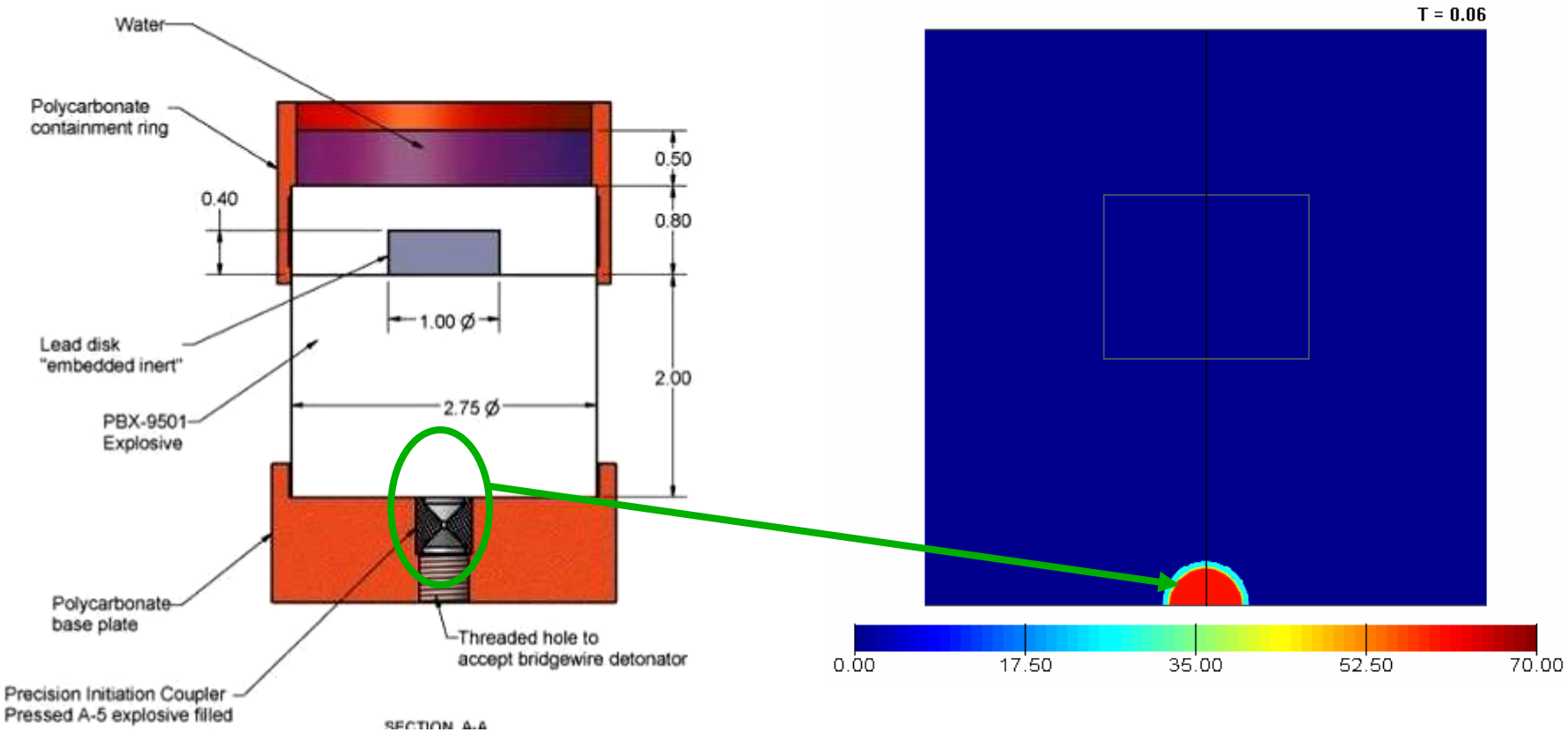
ν = empirical constant to curvature data

κ = mean curvature of the detonation wave

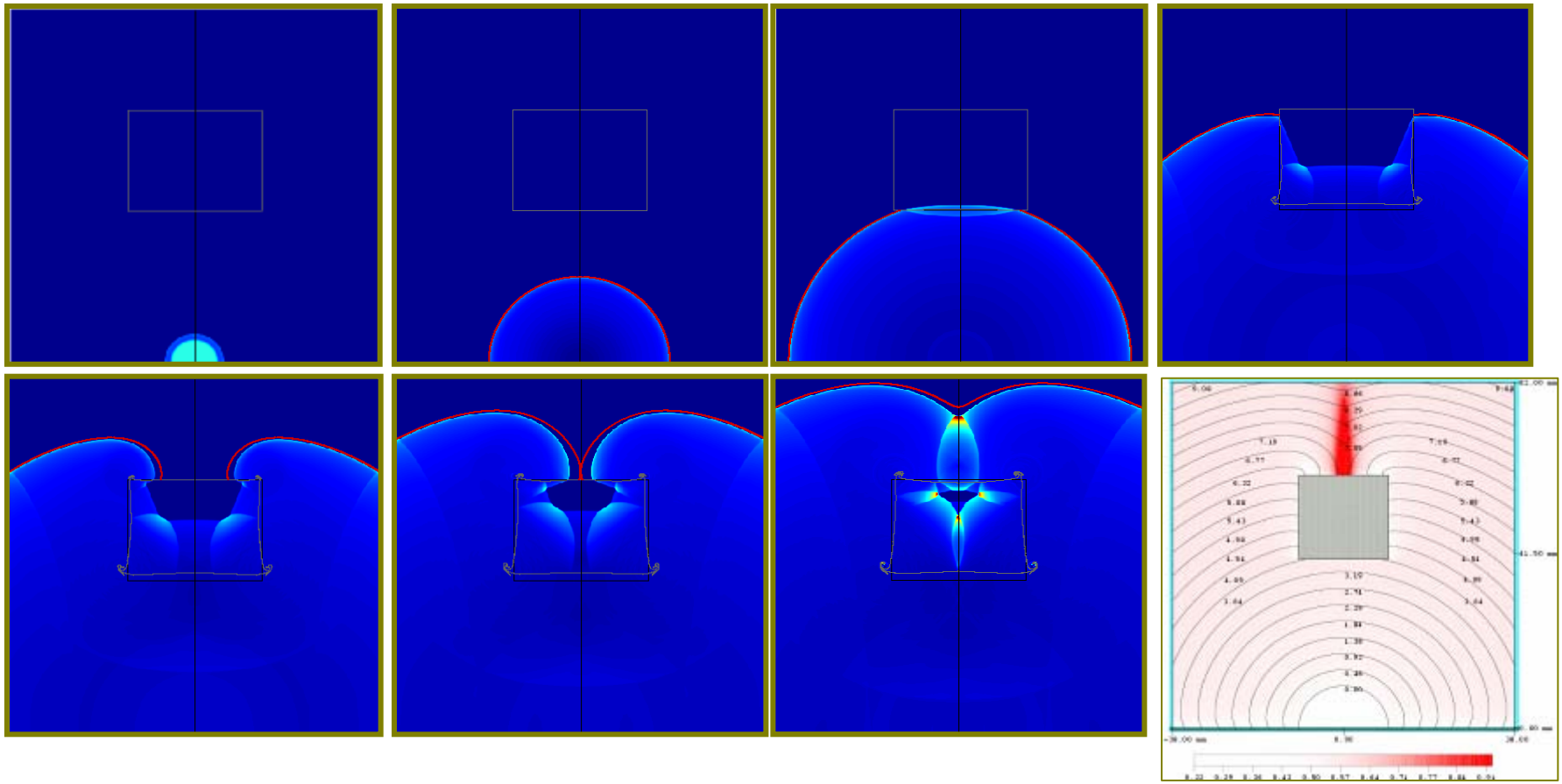


“Passover” Validation Experiment

- Single hemispherical wave transforms into a colliding toroidal structure
- Exercises the DSD wavetracking, EOS, and rate law over a wide range of detonation states
- Assumptions were made on the initial shock radius, starting point of the DSD wavefront

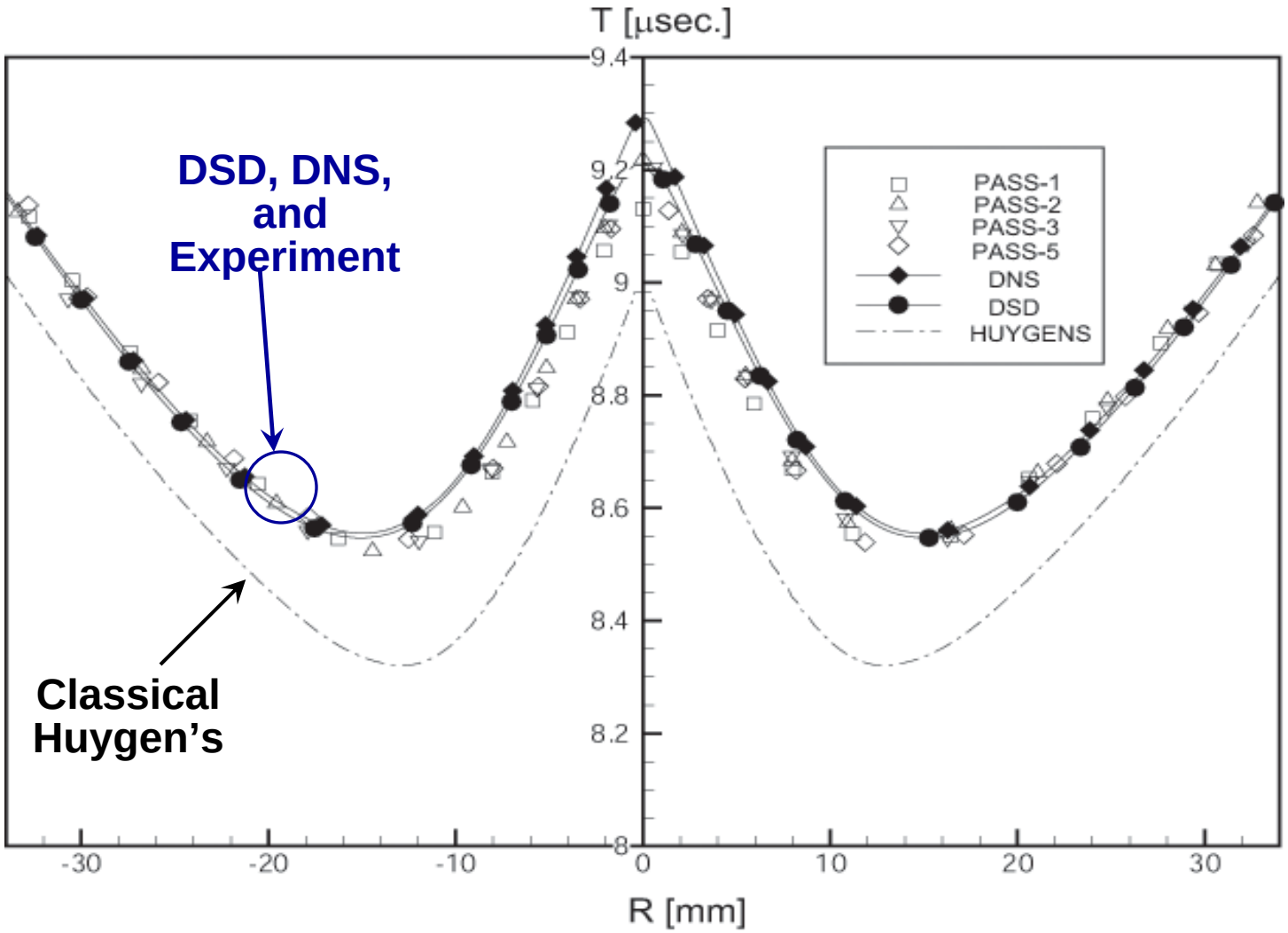


Clips from “Passover” Experiment Video



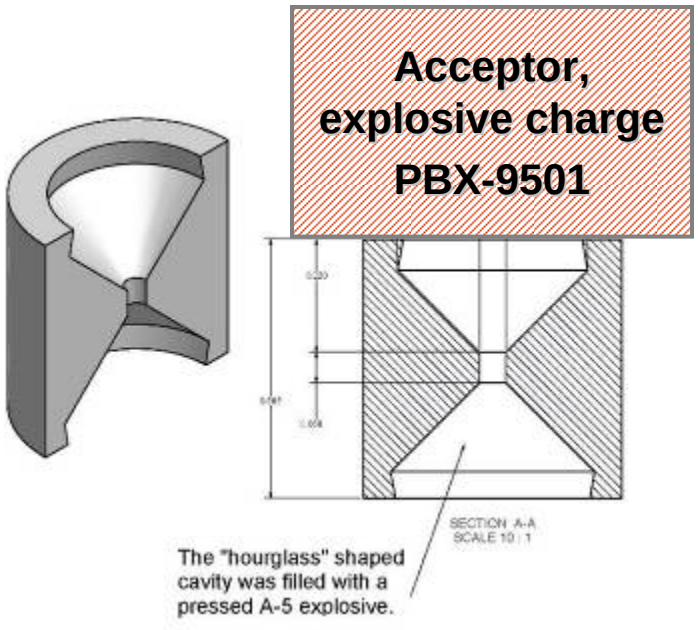
Comparison of "Passover" Experiment

Time-of-arrival record across the top surface of the charge



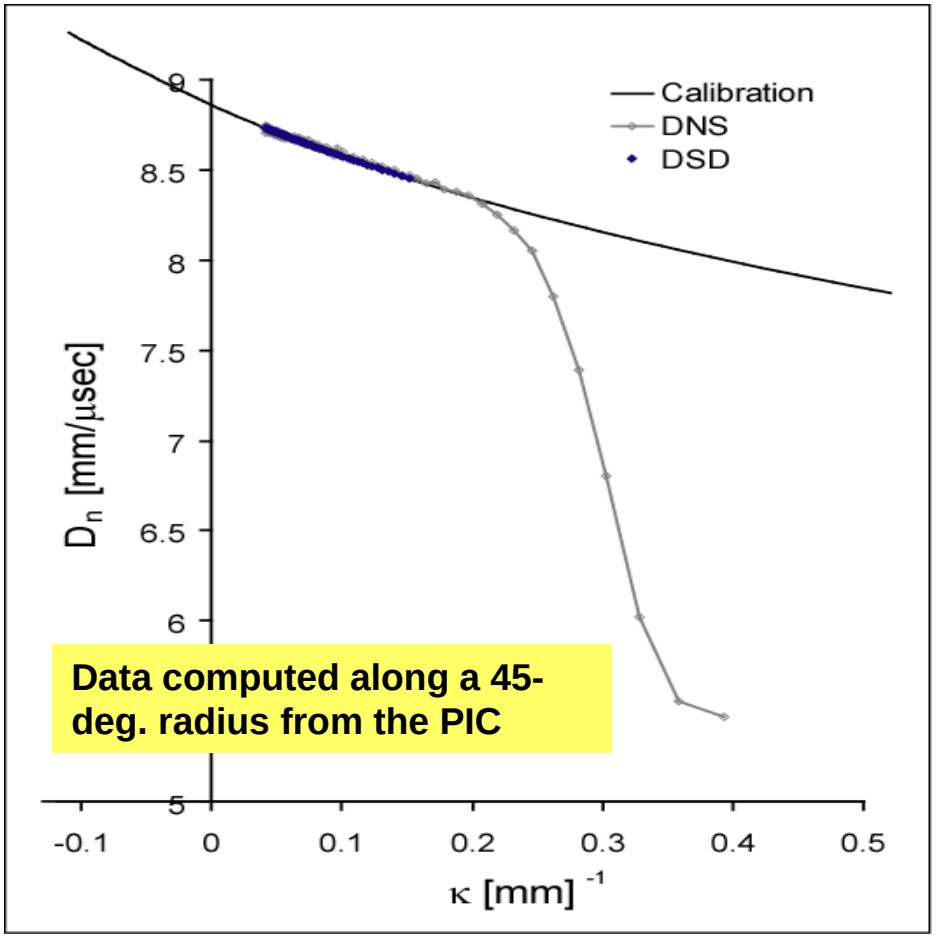
DSD-based Initiation Size

- **Initiation curvature and radius-growth to reach DSD-based assumptions and comparison to Direct Numerical Simulations**



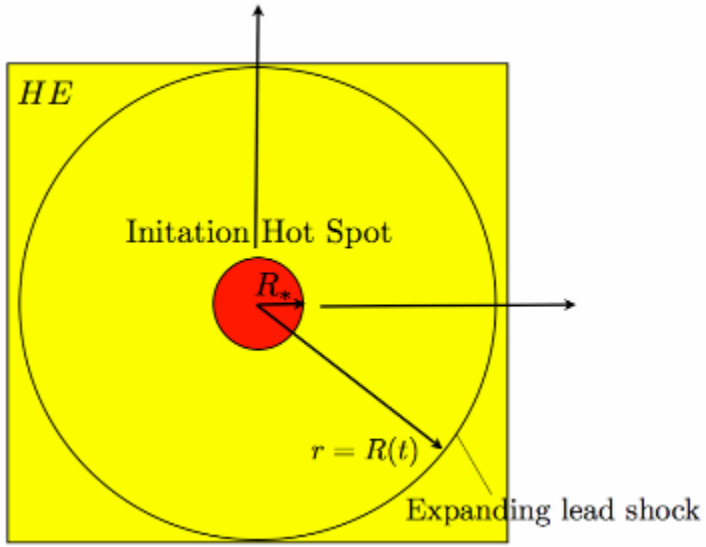
"Precision Initiation Coupler (PIC)"

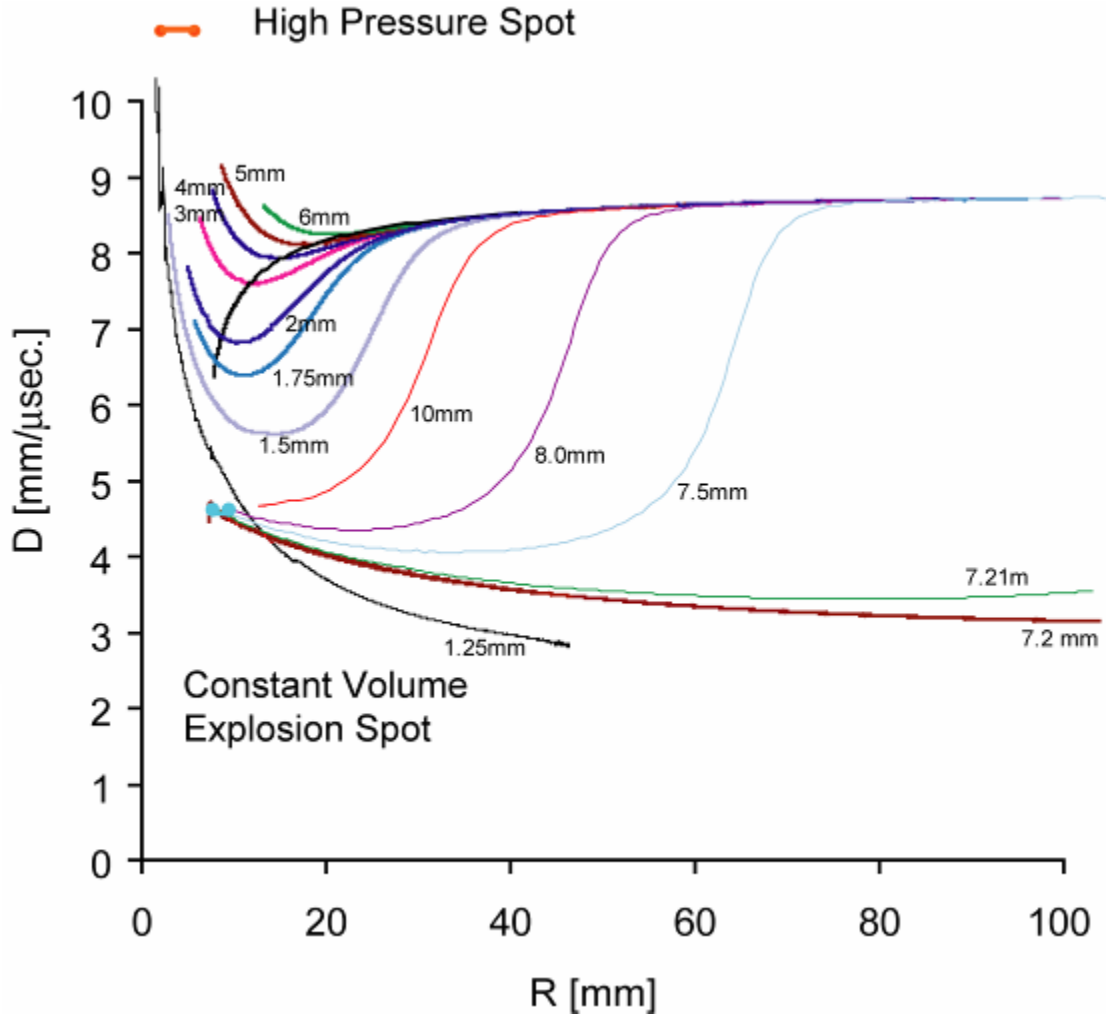
- **Self-centering**
- **680mg of Composition A-5 (98.5% RDX, 1.5% stearic acid)**
- **Near-point initiation (0.052")**



Spot-Size / Initiation Radii

- **Simulated *Dn-R* response for PBX-9501, initiated from various hot-spot radii, both spherical low pressure and high pressure.**





DETERMINATION OF THE LIGHTING RADIUS FOR DETONATION SHOCK DYNAMICS AND CRITICAL IGNITION TRANSIENTS IN CONDENSED EXPLOSIVES

D. Scott Stewart, Sunhee Yoo, and David E. Lambert –
2006 International Detonation Symposium

Characterization Experiments

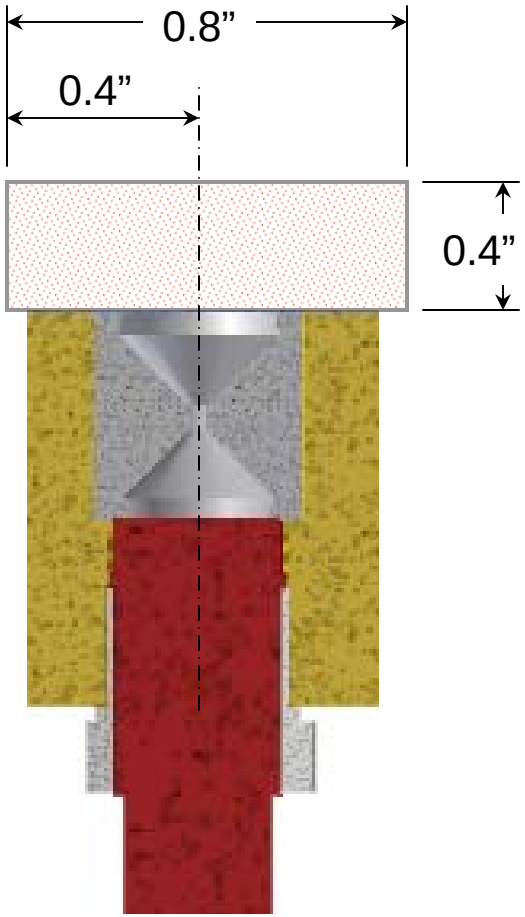
Objective: Characterize the initial shock profile transmitted from the composition A-5 loaded Precision Initiation Coupler to PBX-9501 explosive charges

Approach: "Cut-back Technique" Obtain detonation shock front time-of-arrival data on small, rectangular prisms of explosives

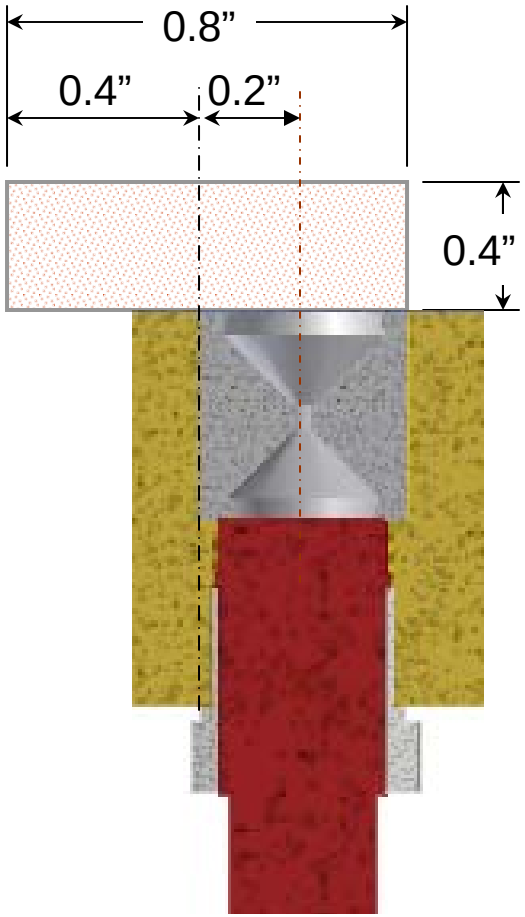
- **Time-of-arrival, wave front contour is the key data**
- **Streak camera and ultra-high speed digital imaging**
  - **Cordin 132a with 100u slit-width, 12mm/us writing rate, TMAX-3200 film**
  - **Imacon 200 Ultra-high speed framing camera at nominally 100-ns interframe time and 15ns duration**
- **PBX-9501 – initiated w/ RP-1 and A-5 PIC system. Needed initial radius for DSD**

Example Charge Configurations

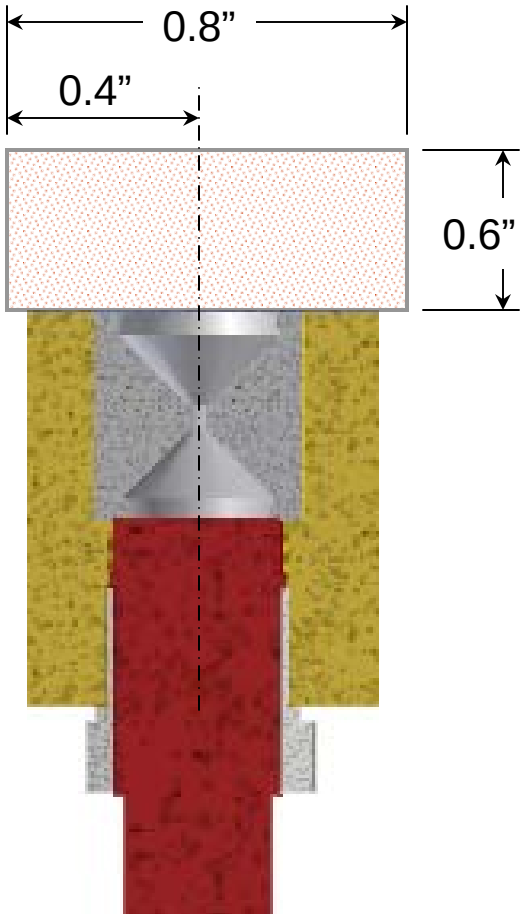
ISC-4



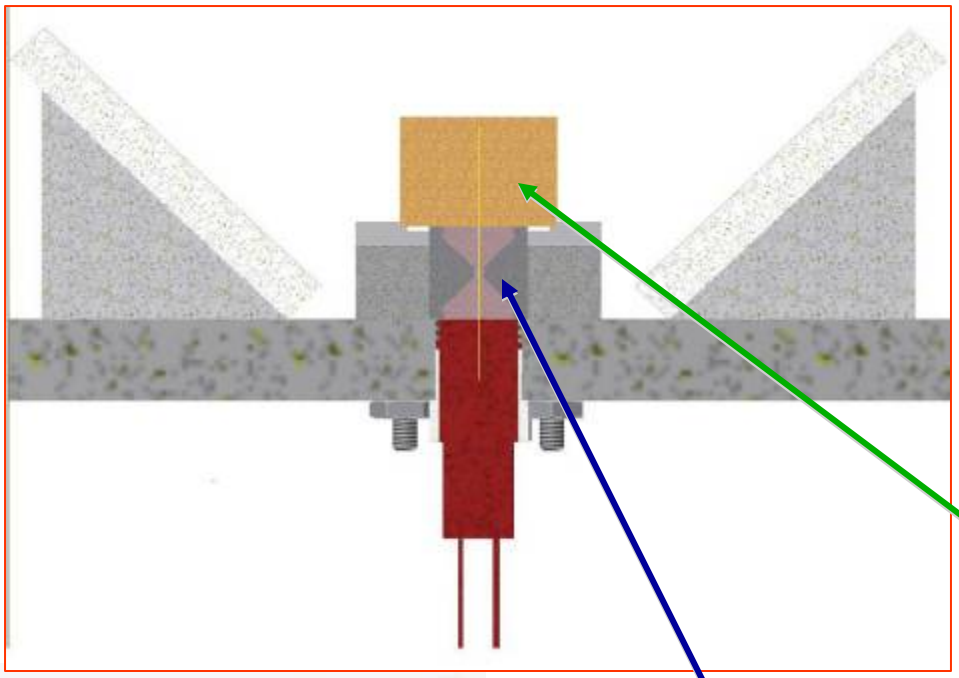
ISC-5

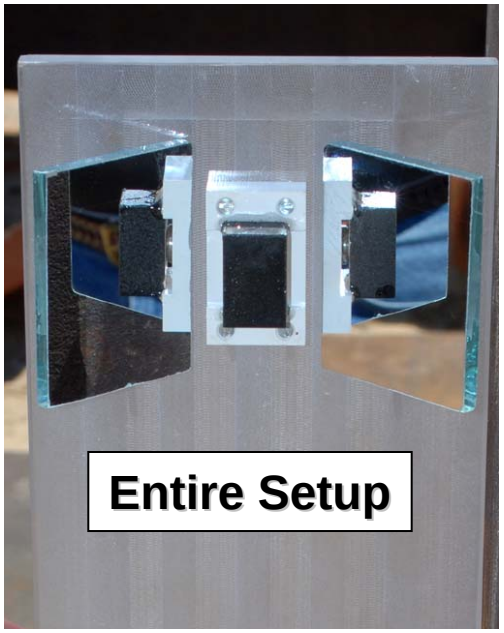


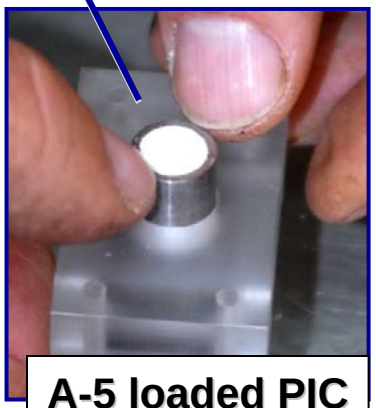
ISC-7 & ISC-8

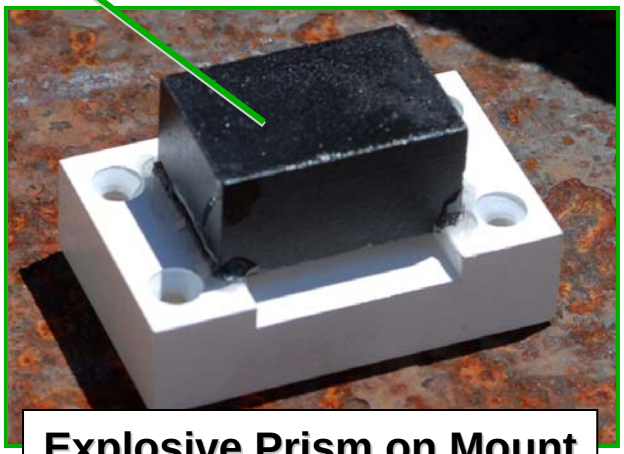


Characterization Experiments

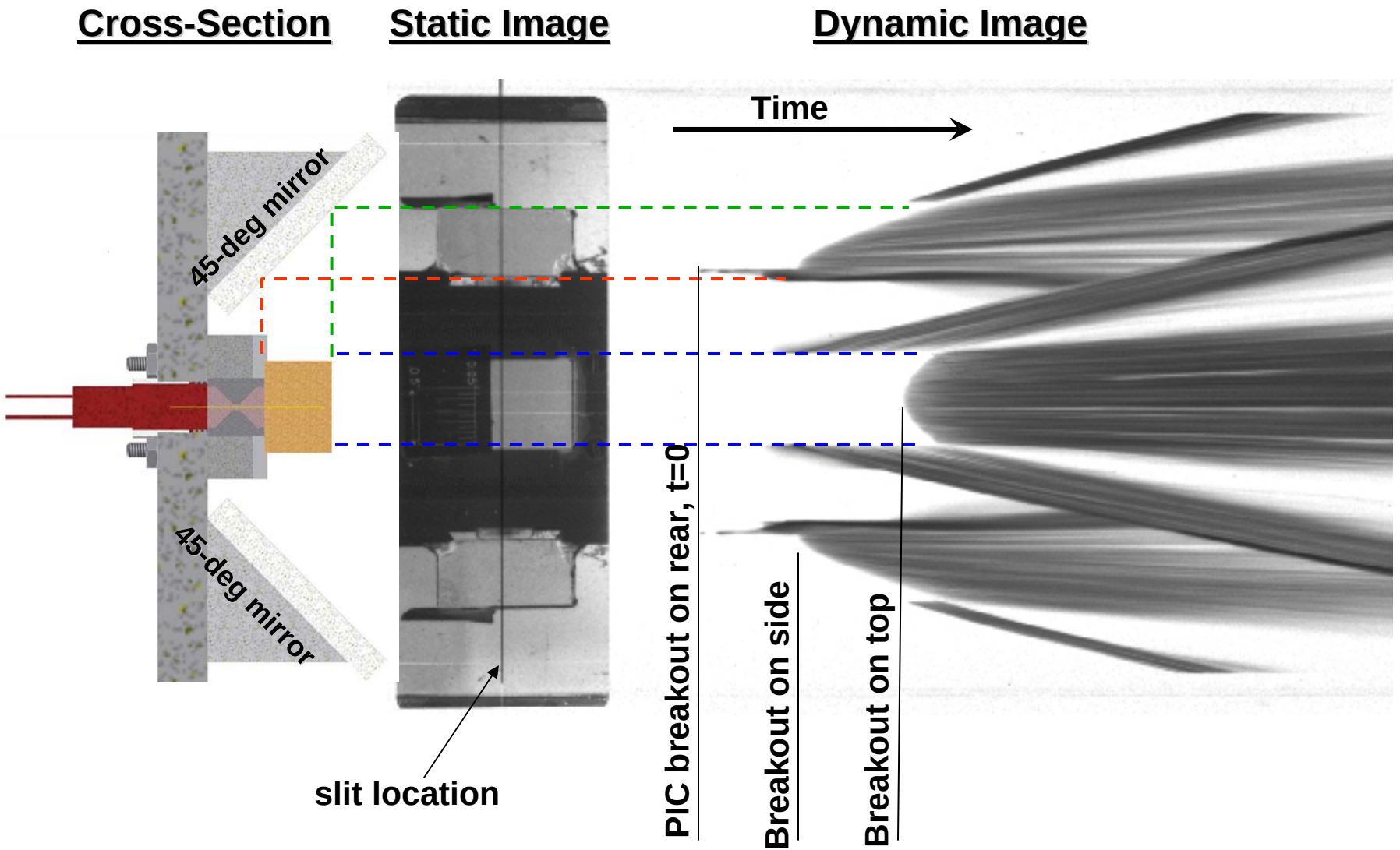






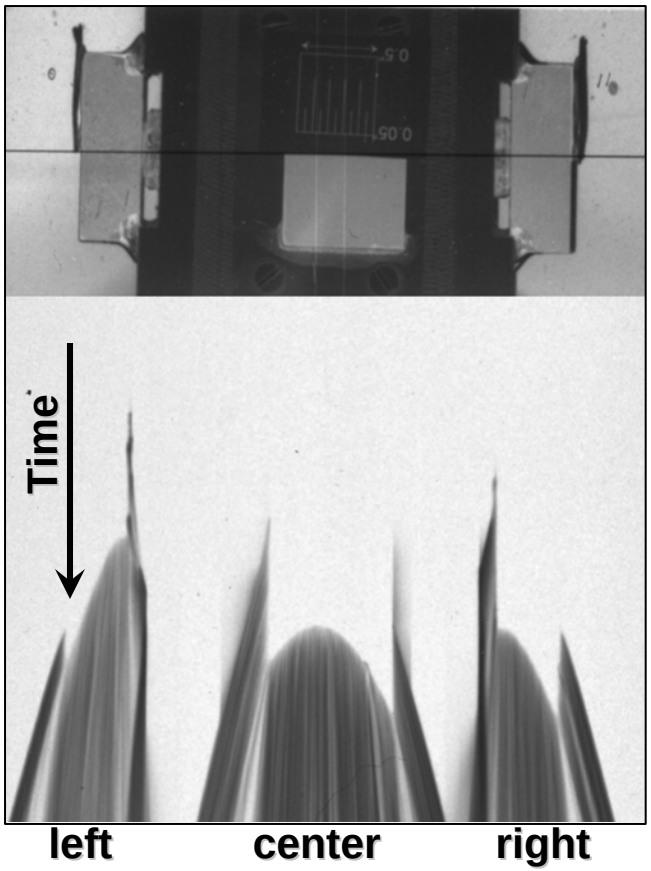


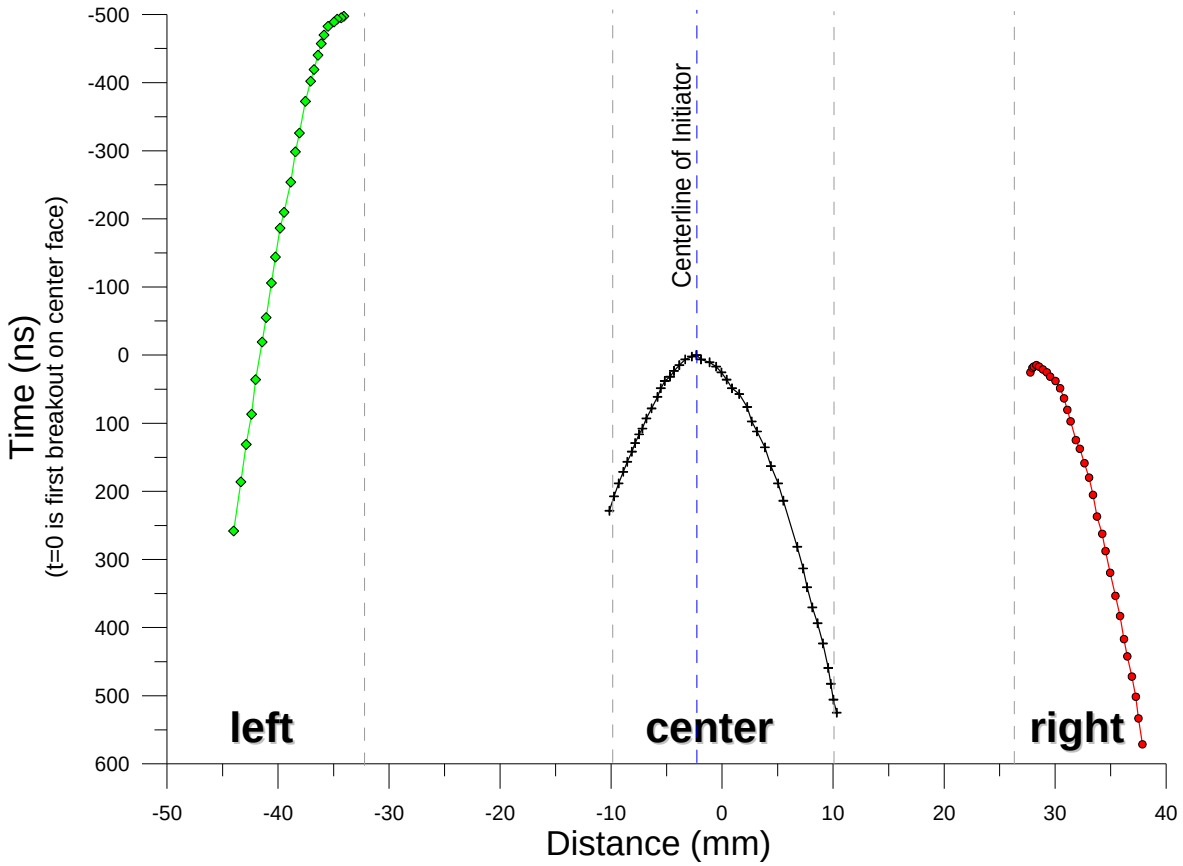
Example Streak Film (PBX-9501)



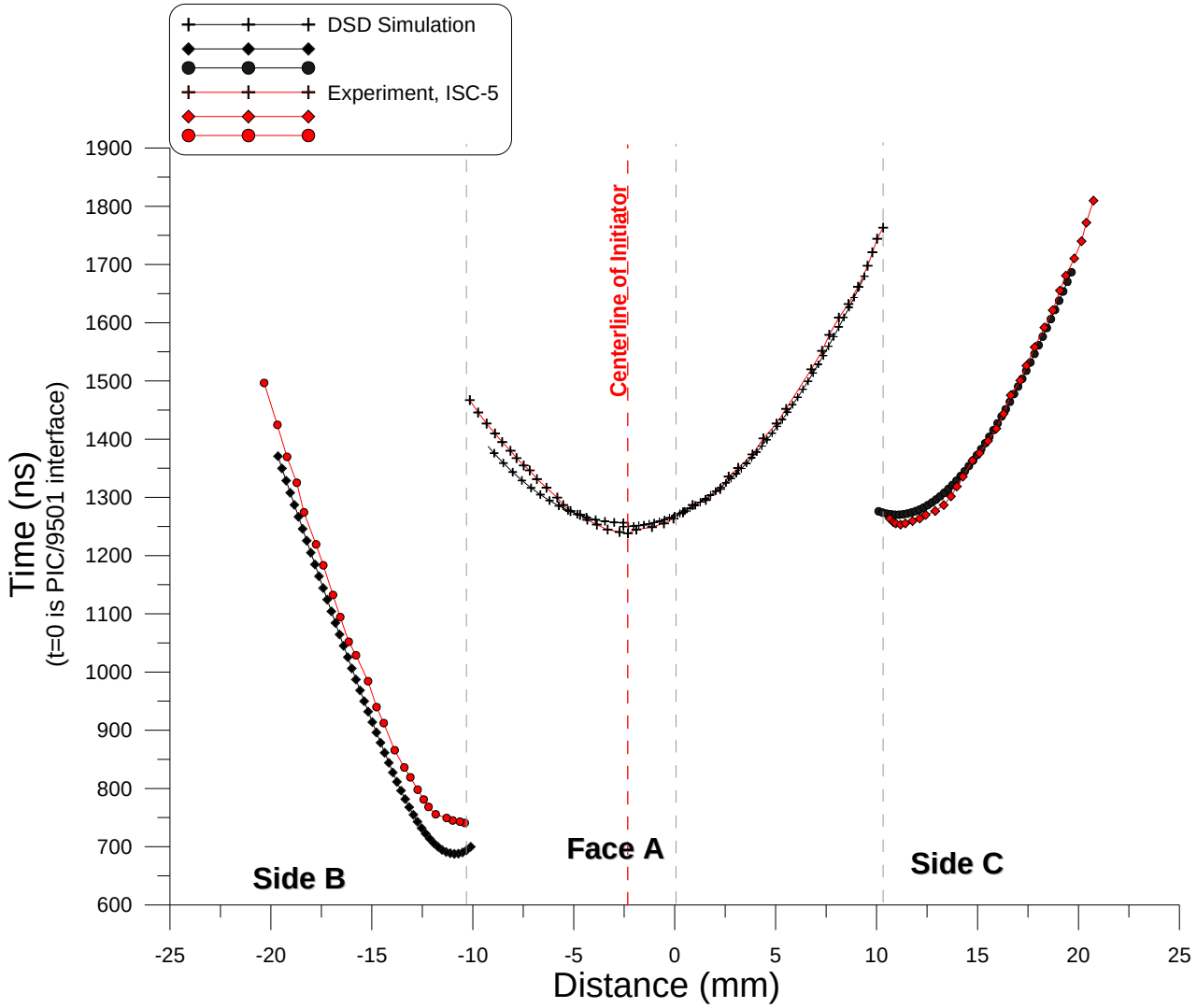
PBX-9501 w/ RP-1/PIC Initiator

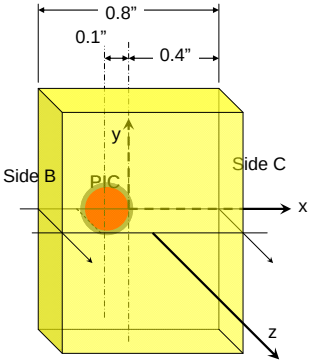
- **RP-1/PIC “Research” initiation system offset from charge centerline by 0.10-inch (2.54mm) towards the ‘left side’**
- **Response, lateral lobes, is a nearly ideal detonation**

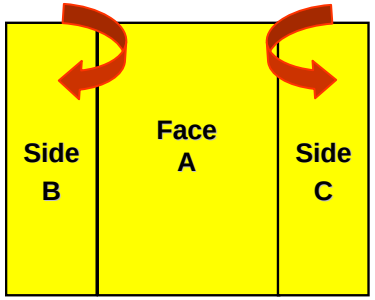


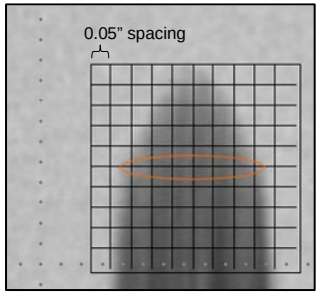


ISC-5 Comparison w/ DSD



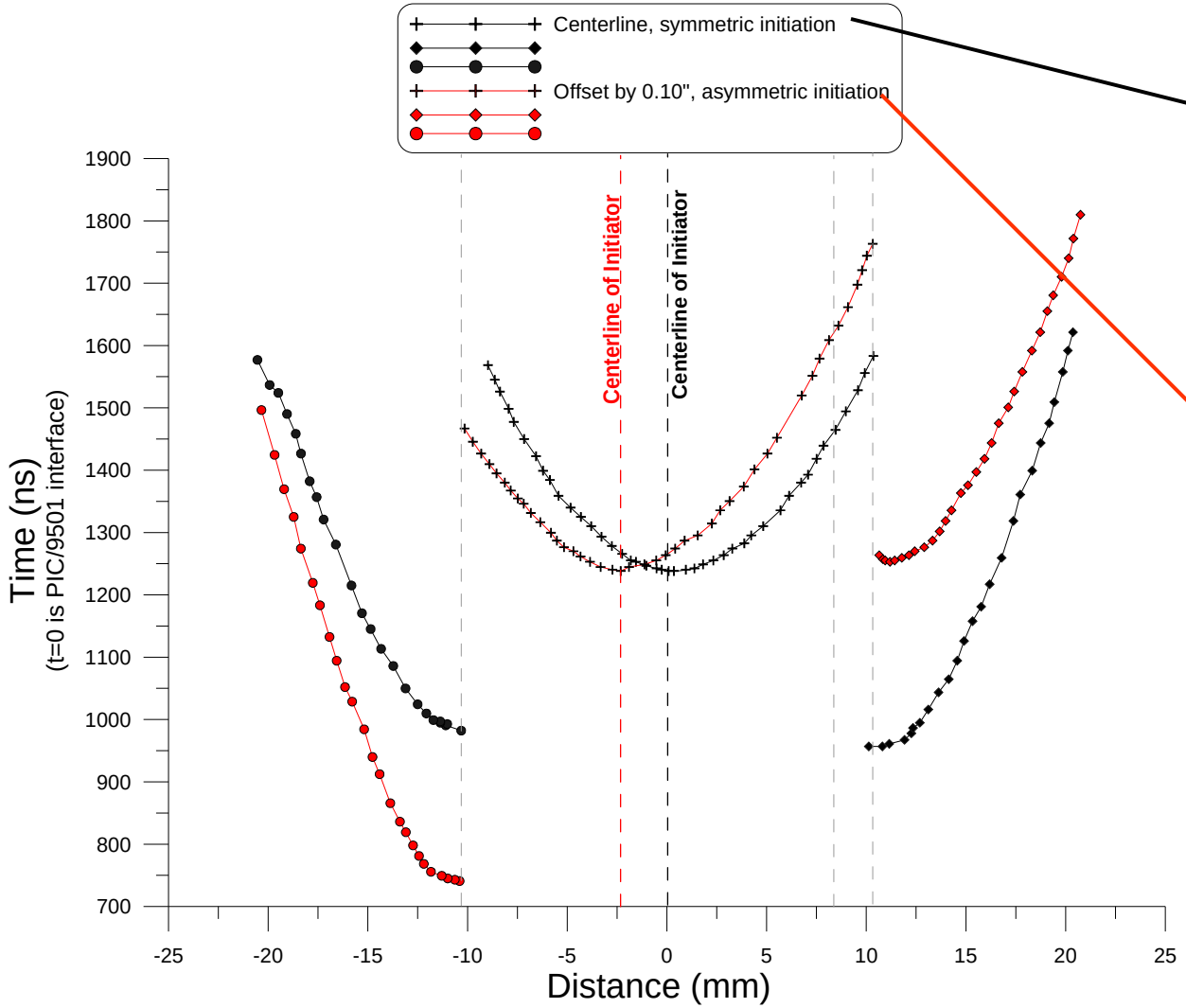


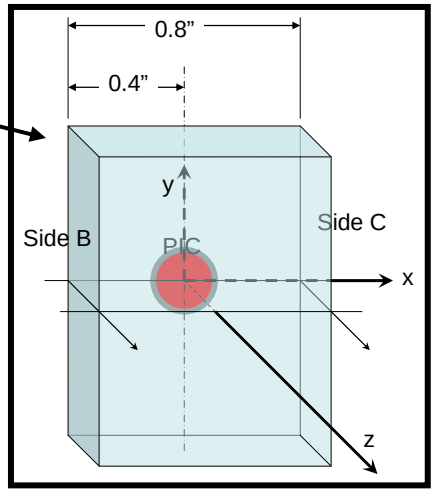


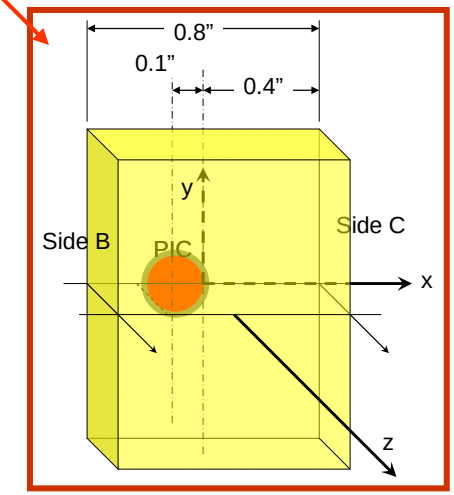


PIC output

Symmetric and Offset Initiation

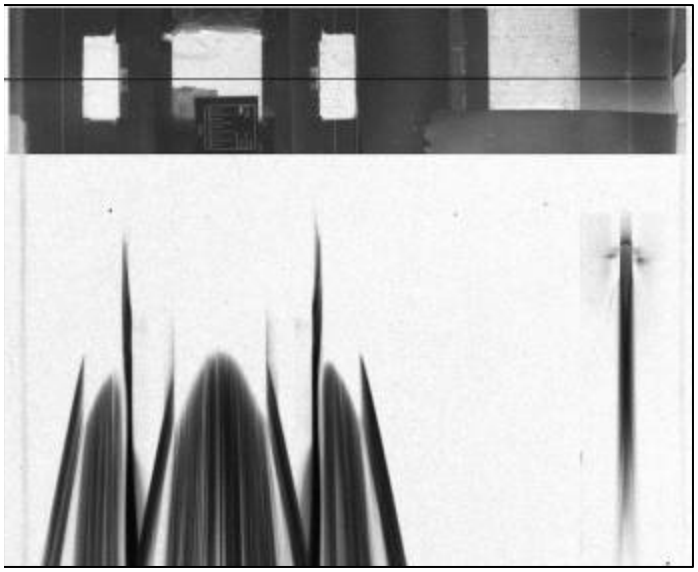




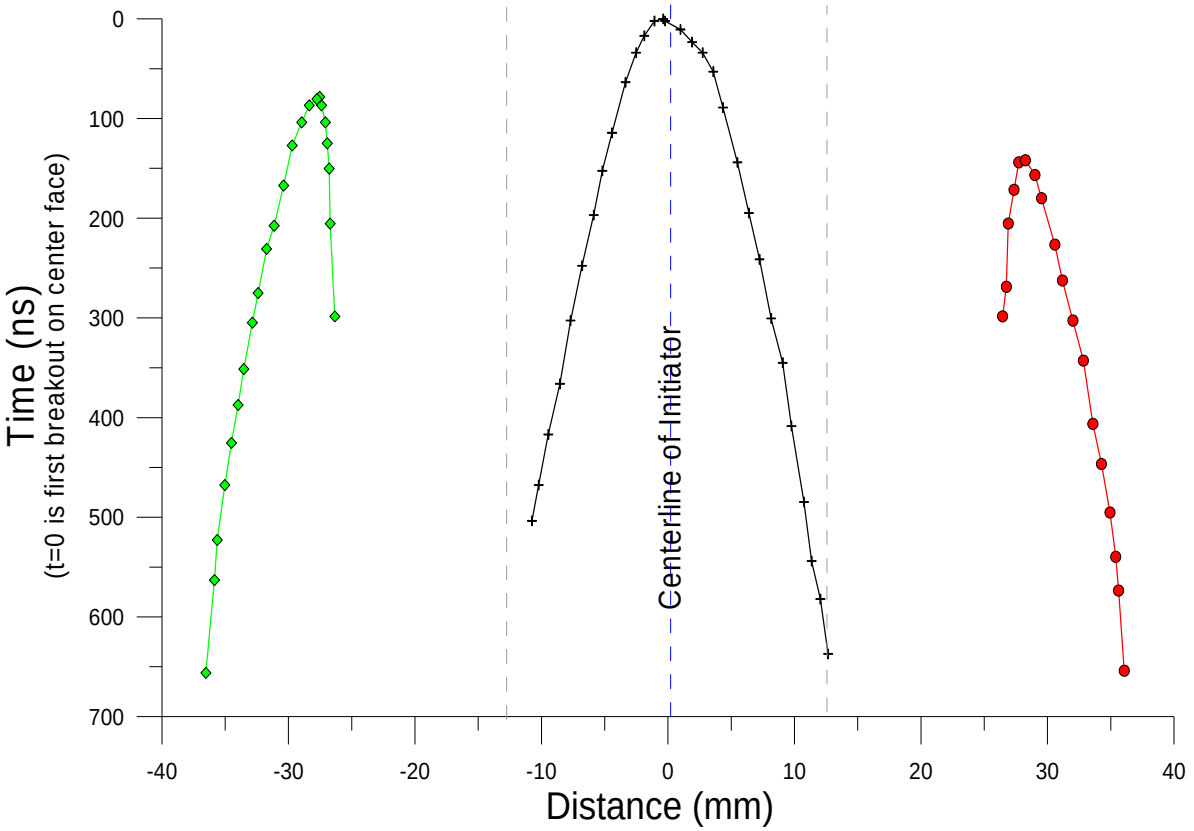


PBXN-9 – Non-Ideal Response (shot ISC-100)

- PBXN-9 Explosive prism, 10-mm height (25mm x 25mm)
- Delayed corner turning



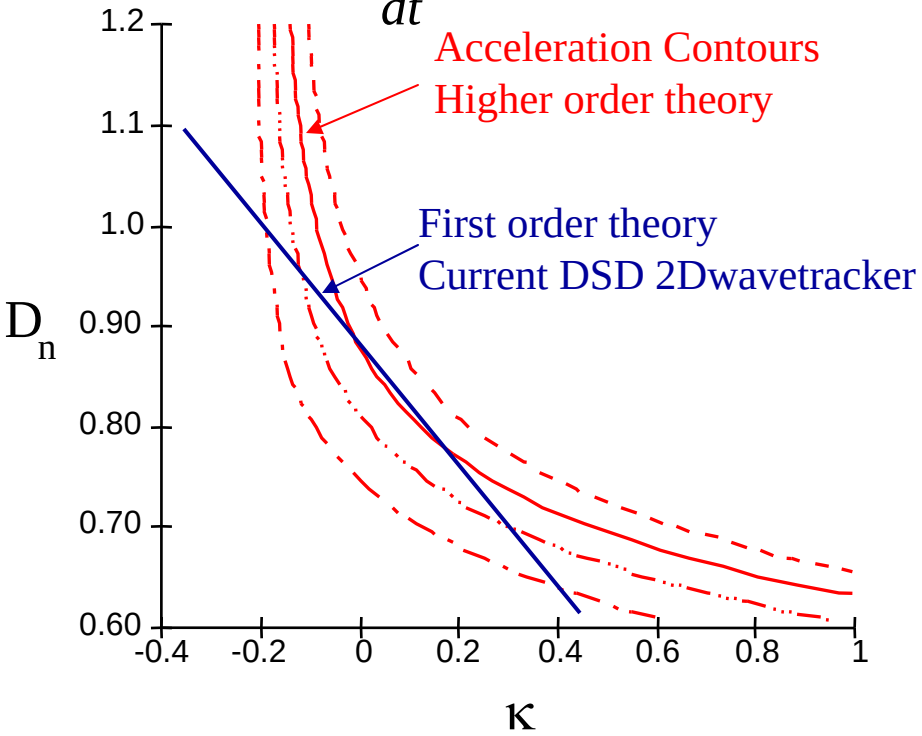
left center right fiducial



Working Towards Diffraction and Transient Detonation States

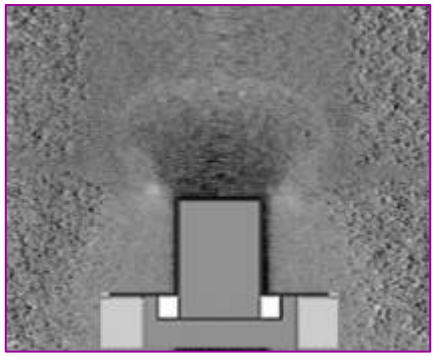
D_n-κ Curves for Nonideal EOS

$$\frac{dD_n}{dt} = A(D_n) - \kappa\ B(D_n)$$

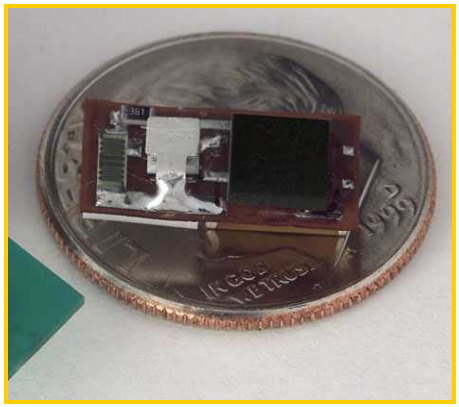


→ The extended theory leads to $\dot{D}_n, D_n, \kappa$ relation and produces hyperbolic PDE's

- Application to miniaturized detonators
- Understanding initiation criteria
- Diffraction of the detonation



Eric Ferm, LANL, DX Division



Summary

- Characterizing the initiation shock transfer, 'Birth of the Wave' is being used to validate the prior assumptions for DSD simulations
- Initial input radius created by the precision initiation coupler (PIC) is under study for analysis of these experiments
- Developing engineering prescriptions of initial shock radii using DSD-based simulations
  - 'Ideal' PBX-9501 shows no corner-turning delay, 'non-ideal' PBXN-9 does show delays in the corner-turning
- Further analysis and extension on these experiments will be a part of transient detonation and shock profile measurements